

# Appendix D

## Cost Benefit Analysis

# **Guide to Benefit Cost Analysis (BCA) spreadsheet**

**(Montgomery County Maryland RAISE BCA.xlsx)**

**Project: Community Connector**

## **Section 1: Introduction**

### **Project Description**

Montgomery County, Maryland, is seeking discretionary grant funding from the US Department of Transportation through the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants program to construct the Community Connector Passageway in Bethesda, Maryland. The passageway will be approximately 0.3 mi in length and will pass beneath Wisconsin Ave (MD 355) and provide direct access to both the MDOT MTA Purple Line Bethesda train station (currently under construction) and the WMATA Red Line Bethesda station. There will also be a new underground bike parking facility with 460 spaces as a part of this project.

### **Background and Assumptions**

A tunnel used to exist until 2017 and it was removed in late 2017. Therefore, some of the walk and bike trips stopped using the CCT. The passageway and the WMATA Purple Line will open in 2026. It is assumed that at that time, the walk and bike trips that left earlier will come back, in addition to the new walk trips due to the Purple Line. There will also be additional bike trips due to the new bike parking.

The trail had occupied the space reserved for the Purple Line transit line which is now under construction. Unless this Community Connector project can be funded and constructed, the CCT will exist at-grade through downtown Bethesda, crossing several streets including the heavily-traveled Wisconsin Avenue. The Community Connector project will connect the CCT both east and west of downtown Bethesda with a safe and efficient multi-use facility and reduce user conflicts at busy city street intersections.

### **Benefits**

With the passageway in place, the number of walk and bike trips crossing Wisconsin Ave will decrease. This will reduce the number of crashes between vehicles, and pedestrians and bikes. With lesser number of pedestrians crossing the streets, the sudden breaking or longer stopping will reduce for the vehicles, saving some travel time for them. There are five types of benefits estimated in this study:

- Journey Quality Pedestrian
- Journey Quality Bike
- Value of Time Car
- Value of Time Truck
- Safety Cost

The benefits and cost calculations are included in the BCA spreadsheet, and the workbook details are presented in the next section.

## Section 2: BCA Spreadsheet

The spreadsheet **Montgomery County Maryland RAISE BCA v2.xlsx** contains inputs, calculations, fixed factors, and a summary to present the benefit cost analysis for each project. This workbook provides transparency for reviewers to identify the inputs and assumption included in the analysis and the enable the ability to perform a sensitivity analysis by adjusting any inputs or fixed factors.

### **Input Tabs**

The primary set of inputs are entered into the Project Costs, Travel Demand Characteristic (TDC), Crash Reduction, and Fixed Factors tabs.

**Traffic Data:** Traffic data tab includes information about the Base and Build counts for pedestrian and bikes, traffic volumes for vehicles (auto and truck), calculation of vehicles VMT, and crash rates. It also includes calculated growth rates for bikes, pedestrians, and vehicles.

**Assumptions:** It includes the various assumptions used in travel data and benefits calculations, which are not in the “Fixed Factors” tab.

**TDC:** Travel Demand Characteristic inputs are entered in this tab for the following performance metrics: pedestrian and bike count and person miles traveled (PMT), auto and truck vehicle miles travelled (VMT), vehicle hours travelled (VHT), bike, pedestrian, and vehicles crashes, for both the Base and Project Scenario. The values were entered for 2026 and interpolated or extrapolated for all other years are using a compound annual growth rate (CAGR).

**Fixed Factors:** This tab includes the default values and assumptions from 2022 BCA Guidance including - value of time, average vehicle occupancy, improvement related benefits, and crash monetized values.

**Project Costs:** In units of millions of dollars, capital and operations & maintenance costs are entered into this tab by year (rows) and type of expenditure (columns) for both the Base and Project Scenarios.

### **Calculation tabs**

The remaining tabs present intermediate calculations, discounted values, and a summary of all benefits and costs (using 3% and 7% discount rates).

**Benefit Calculations:** Presents the monetized results of applying the TDC and fixed factors for the Project and Base scenarios. This tab provides transparency into the monetized values for each category of benefit.

**Benefits Summary:** Using the values from the ‘Benefit Calculations’ tab, values in the Base Scenario are subtracted from the Project scenario and presented in units of millions of dollars in undiscounted terms and also applying a 3% and 7% discount rate.

**Cost Summary Discounted:** Includes startup (e.g. construction) and operations and maintenance costs for all years and applies a discount rate of 3% and 7%.

**BCA Summary:** Presents the summary benefit results by category of benefit, cost summary, Net Present Value, and benefit cost ratio in undiscounted terms and using a 3% and 7% discount rate.

## Section 3: Calculations

This section describes the background data that was used in the spreadsheet, the assumptions used, and how the user can modify the data and view the updated results.

### Pedestrian and Bike Traffic Counts

The Pedestrian and Bike Traffic Counts for the CCT were obtained from CCT trail count website (<https://data.eco-counter.com/public2/?id=100016888>). The counts were available from 2015 to 2022 for each day. They were aggregated by monthly median, and then average of all months was calculated to get the daily counts for each year. The daily counts and the growth are shown in **Table 1**. The growth is not consistent as per this table, and therefore another set of daily counts was created using maximum of all months in each year, the results of which are shown **Table 2**. The growth was calculated from **Table 2**, by averaging the growth values in 2016 and 2017, which are two years before the tunnel was removed as well as before the COVID. The growth was estimated to be 7%.

**Table 1** shows that the counts reduced in 2018. This is because the tunnel was removed and so some trips stopped taking the trail. In the opening year 2026, these trips are assumed to come back. There will be additional walk trips due to the purple line and additional bike trips due to the new parking with 460 spaces. In the opening year 2026, the Base and Build trips were calculated as follows:

#### Pedestrian

- 2026 Base:
  - 2018 trips that remain on the trail and grown by 7% annually to 2026.
  - Trips due to purple line – walk trips were calculated using 2030 and 2040 Bethesda purple line station boardings and making a conservative assumption that 10% of total boardings are walk trips and 50% of those use tunnels.
- 2026 Build:
  - 2017 trips grown by 7% annually to 2026. They include all trips and do not exclude the ones that went away when tunnel was closed in 2018.
  - Trips due to purple line – same as 2026 Base trips.

#### Bicycle

- 2026 Base:
  - 2018 trips that remain on the trail and grown by 7% annually to 2026
- 2026 Build:
  - 2017 trips grown by 7% annually to 2026. They include all trips and do not exclude the ones that went away when tunnel was closed in 2018.
  - 460 additional bike trips, assumed to phase in linearly from 2026 to 2030, reaching full capacity in 2030

All the input values including bike and pedestrian counts for Base and Build, and Bethesda station boardings are present in the sheet **Traffic Data** and shown in yellow highlighted cells. The assumptions including annualization factor, growth rates, etc. are shown in sheet **Assumptions**.

**Table 1: Daily counts based on average of all months**

			Year by Year growth	
Year	Ped	Bike	Ped	Bike
2015	1,242	810		
2016	1,400	857	12.7%	5.8%
2017	1,395	810	-0.3%	-5.5%
2018	1,144	621	-18.0%	-23.3%
2019	1,185	698	3.6%	12.4%
2020	1,535	867	29.5%	24.1%
2021	1,341	506	-12.6%	-41.6%
2022	1,203	236	-10.3%	-53.5%

**Table 2: Daily counts based on maximum of all months**

			Year by Year growth	
Year	Ped	Bike	Ped	Bike
2015	1,529	1,131		
2016	1,630	1,048	6.6%	-7.3%
2017	1,757	1,080	7.8%	3.0%
2018	1,290	904	-26.6%	-16.3%
2019	1,347	872	4.4%	-3.5%
2020	1,712	1,088	27.1%	24.7%
2021	1,500	641	-12.4%	-41.1%
2022	1,440	347	-4.0%	-45.8%

Note: All the input values in the sheet **Traffic Data** are highlighted in yellow and can be modified if needed. The cells highlighted in green have calculated values, that are inputs to other sheets like **TDC**.

The content of the **Assumptions** sheet is shown in

**Table 3.** The sheet has default values and “User Override” column where user can enter a different value if needed.

**Table 3: List of Assumptions**

Variable	Default	User Override	Used
Annualization Factor	260		260
Purple Line walk riders annual growth	0.14%		0.14%
Walk-to-station share of boardings at Bethesda	10%		10%
Share of walk-to-station using tunnel	50%		50%
Vehicle traffic growth rate	1.10%		1.10%
Ped growth rate			
Until 2026	7.0%		7.0%
2036 and later (interpolate for 2027-2035)	1.1%		1.1%
Trail length (mi)	0.3		0.3
Distance (Elm St. to MD 410)	0.18		0.18
Average vehicle speed in Base (mph)	25		25
Improved travel time for vehicles (sec)	5		5
Crash Modification Factors (CMF)			
Pedestrian	0.1		0.10
Bike	0.1		0.10
Vehicles	0.55		0.55
% Trips crash that receive benefits			
Pedestrian	50%		50%
Bike	50%		50%
Vehicles	50%		50%

**Vehicle Traffic Counts**

The traffic counts for auto and truck were calculated using MDOT traffic counts for the segment Wisconsin Ave (MD 355) between Elm St and E-W Highway (MD 410). The segment length is 0.18 mile. The collected counts information is shown in **Table 4**. Pre-COVID year 2019 traffic were used to estimate the 2026 volumes. The growth rates were not consistent, and therefore all “positive” growth rates between 2013 and 2021 were averaged and calculated to be 1.1%. This traffic growth was conservative.

The Vehicle Miles Traveled (VMTs) were calculated using the segment length and auto and truck volumes. The benefits calculation required Vehicle Hours Traveled (VHT) information in the Base and the Build. In the Base, average speed of 25 mph was assumed. A travel time savings of 5 sec per vehicle was assumed, estimating the Build speed to be 31 mph.

The input values of 2026 volumes are highlighted in yellow in the sheet **Traffic Data**. The growth rate, speed, and time savings assumptions are shown in the sheet **Assumptions**.

**Table 4: Vehicle Traffic counts**

Year	AADT	AAWDT	SU	CU	Auto	Truck	Growth
2012	40,630	43,880			40,630	-	
2013	40,711	43,971			40,711	-	0.20%
2014	40,592	43,432			40,592	-	-0.30%
2015	38,260	40,940	2%	1%	37,112	1,148	-5.70%
2016	38,991	41,721	2%	1%	37,821	1,170	1.90%
2017	39,932	42,732	2%	1%	38,734	1,198	2.40%
2018	39,573	42,343	2%	1%	38,386	1,187	-0.90%
2019	39,574	41,954	2%	1%	38,387	1,187	0.00%
2020	33,045	35,695	2%	1%	32,054	991	-16.50%
2021	28,620	30,620	2%	1%	27,761	859	-13.40%

**Crash Rates & Crash Modification Factors**

The crash counts were obtained for the Montgomery County website (<https://data.montgomerycountymd.gov/Public-Safety/Crash-Reporting-Incidents-Data/bhju-22kf>). A project area was defined as shown in **Figure 1**, and the vehicle, pedestrian and bike crashes were selected within it. The counts were aggregated by each year between 2015 and 2022 and shown in **Table 5**.

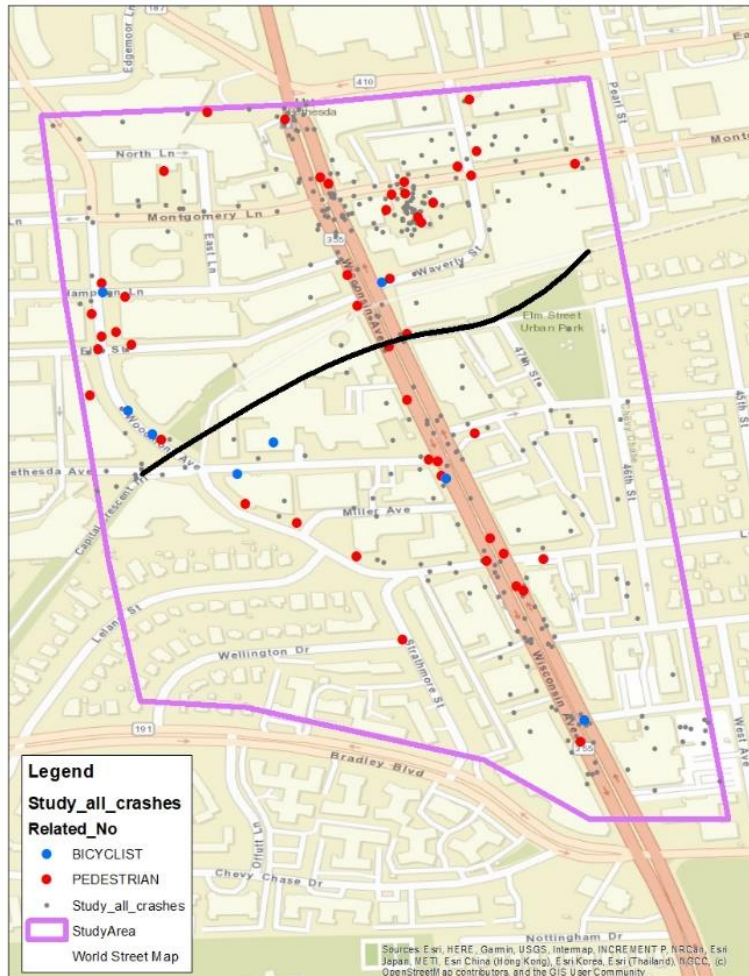
**Table 5: Crash counts**

Year	Bicyclist		Pedestrian		Auto	
	Injury	Property Damage	Injury	Property Damage	Injury	Property Damage
2015	3	0	9	0	22	50
2016	1	0	5	0	13	46
2017	2	0	11	0	13	61
2018	0	0	6	0	6	38
2019	1	0	10	0	14	29
2020	0	0	4	0	3	16
2021	1	0	1	1	10	26
2022	0	0	0	0	1	4

To calculate the crash rates, all the values - vehicle traffic counts, pedestrian and bike counts, and number of crashes, were selected for the year 2017. For pedestrian and bike, the crash rates were calculated as crash per pedestrian or bike, while for vehicles, they were based on crash rate per VMT. Also, it is assumed that not all the crashes will receive the benefits of the new tunnel, therefore, the percentage of crashes that will receive benefits are assumed to be 50% for each of three - pedestrian,

bike, and vehicles. Crash rate calculations are in the sheet **Traffic Data**. All the input values are shown in yellow color in the same sheet, and the assumptions like crash modification factors, percentage of trips benefiting from crash reduction are in sheet **Assumptions**.

**Figure 1: Project Area**



## Travel Demand Characteristics

The sheet **TDC** has year-by-year calculations of various performance metrics for each scenario, the Base, and the Build. For most of the measures, the 2026 values are calculated in the **Traffic Data** sheet and are highlighted in green in that sheet. The growth for the measures is either based on constant annual growth rate or have different growth rates for some years. Constant growths are presented in the **Assumptions** sheet, while other growths are either in **Traffic Data** or used directly in the **TDC** sheet. The **TDC** sheet only includes calculations and does not include any direct user-input values.

More information on the growth is presented by below for each measure.

- Pedestrians without Purple Line - The growth reduces from 7% in 2026 to 1.1% in 2036 (10 years) and then remain at 1.1% which is same as vehicle traffic growth

- Pedestrians due to Purple Line – The growth rate is same as purple line boardings at Bethesda (0.14%)
- Bike - The growth reduces from 7% in 2026 to 1.1% in 2036 and then remain at 1.1%
- New bike trips in the Build (due to additional parking) grow linearly from 2026 to 2030, reaching full capacity in 2030
- Auto and Truck VMT growth rate is constant at 1.1%

Other measures in this tab are calculated using above-mentioned measures and other assumptions, as mentioned below:

- PMT (person miles traveled) – based on ped/bike counts and trail length
- VHT (vehicle miles traveled) – based on VMT and speed values
- Crash – based on VMT and crash rates

## **Benefits**

The sheet **Benefit Calculations** has value of time and safety costs calculated for the Base and Build scenarios. It also includes the pedestrian and bike journey quality benefits due to the project. These benefits are calculated for the Base pedestrian and bike trips as they are not new trips and will perceive the benefits. This sheet only includes calculations and does not include any direct user-input values.

The **Benefits Summary** sheet has benefits calculated from cost savings between the Base and the Build scenarios. The sheet only includes calculations and does not include any direct user-input values.

## **Costs**

The **Project Costs** sheet includes the capital and O&M cost inputs.

**Cost Summary** sheet Discounted has cost values discounted at 3% and 7%.

## Results

**BCA Summary** sheet shows the Benefit/Cost Ratio and the Net Present Value. The results are presented in **Table 6**.

**Table 6: Benefit Cost Summary**

Benefit	3% discount rate (in \$millions)	7% discount rate (in \$millions)	Undiscounted (in \$millions)
Journey Quality Ped	\$2	\$1	\$4
Journey Quality Bike	\$4	\$2	\$9
Value of Time Car	\$11	\$5	\$22
Value of Time Truck	\$0	\$0	\$1
Safety Cost	\$111	\$50	\$234
<b>Total Benefits</b>	<b>\$129</b>	<b>\$58</b>	<b>\$270</b>

Costs	3% discount rate (in \$millions)	7% discount rate (in \$millions)	Undiscounted (in \$millions)
Capital Investment Costs	\$47.6	\$39.2	\$55.3
Operation and Maintenance Costs	\$1.0	\$0.5	\$2.0
<b>Total Costs</b>	<b>\$49</b>	<b>\$40</b>	<b>\$57</b>

	3% discount rate (in \$millions)	7% discount rate (in \$millions)	Undiscounted (in \$millions)
Net Present Value	\$80	\$18	\$213
	3% discount rate (in \$millions)	7% discount rate (in \$millions)	Undiscounted (in \$millions)
<b>Benefit/Cost Ratio</b>	<b>2.7</b>	<b>1.5</b>	<b>4.9</b>

County:	MONTGOMERY		Municipality:	NONE	
Prefix:	MD	Route NO:	355	Suffix:	
Mile Point:	1.54				
Location:	MD355-.10 MI S OF MD410				
Begin Sect:	0		End Sect:	3.22	
Station Desc:	Washington DC/L to Cedar Lane				
Func Class:	14-URBAN OTHER PRINCIPAL ARTERIAL		Location ID:	B2863	

Year	AADT	AAWDT	Single Unit	Combination Unit	K Factor	D Factor	North East Split	South West Split	Dir In Peak Hour
2021	28,620	30,620	2	1	8.51	59.02	51.03	48.97	NORTH
2020	33,045	35,695	2	1	7.24	52.16	50	50	NORTH
2019	39,574	41,954	2	1	7.24	52.16	50	50	NORTH
2018	39,573	42,343	2	1	7.24	52.16	50	50	NORTH
2017	39,932	42,732	2	1	7.24	52.16	50	50	NORTH
2016	38,991	41,721	2	1	7.24	52.16	50	50	NORTH
2015	38,260	40,940	2	1	7.24	52.16	50	50	NORTH
2014	40,592	43,432			7.81	53.84	53.02	46.98	NORTH
2013	40,711	43,971			7.81	53.84	53.02	46.98	NORTH
2012	40,630	43,880			7.81	53.84	53.02	46.98	NORTH

Note

<b>AADT:</b>	Annual Average Daily Traffic is the number of vehicles expected to pass a given location on an average day of the year.
<b>AAWDT:</b>	Annual Average Weekday Traffic is the number of vehicles expected to pass a given location on an average Weekday (Monday – Friday).
<b>Single Unit:</b>	Percentage of Trucks (FHWA Classes 4 -7).
<b>Combination Unit:</b>	Percentage of Trucks (FHWA Classes 8-13).
<b>K Factor:</b>	Proportion of Annual Average Daily Traffic occurring in the 30th highest hour volume for Continuous count station and Peak hour volume for Short duration count stations.
<b>D Factor:</b>	Percentage of traffic moving in the peak direction during the 30th highest hour volume for Continuous count station and Peak hour volume for Short duration count stations.
<b>North East Split:</b>	Percentage of traffic in the North or East Direction.
<b>South West Split:</b>	Percentage of traffic in the South or West Direction.
<b>Peak Hour Direction:</b>	The direction with largest volume in the peak hour.

Wisconsin Avenue Traffic Data  
taken at Elm Street Provided by  
MDOT SHA